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Renaissance Team Data Services Working Group Transition Plan for the Advanced Composition Explorer (ACE)

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Renaissance Team Data Services Working Group Transition Plan for the Advanced Composition Explorer (ACE)

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Section 1. Introduction

At the start of the Renaissance effort, Advanced Composition Explorer (ACE) was chosen as the first transitional Renaissance mission. The ground data system for this mission is to be a first step toward the Renaissance goal of integrated mission support environments with routine operations centralized in the Mission Operations Center (MOC).

The Renaissance team chartered the Data Services Working Group to take a more detailed look at the ACE requirements for data processing and data management. These areas include level-zero processing (LZP); real-time data processing; and file, database, and log services needed to support applications defined by other working groups. The working group has the responsibility to identify the building blocks needed for the ACE MOC and specifically the software to be considered Renaissance "building blocks" in the ACE ground data system. These building blocks are expected to be general and reusable beyond the ACE mission.

The group focused on building blocks at the *software element* level (as defined by the current *Proposal for a Baseline Software Backplane Architecture* from the Architecture Working Group). Software elements are those basic software components that can be "plugged into" the standard Renaissance *software backplane* architecture. A software element may itself consist of lower level reusable subelements.

A major driver in the deliberations of the working group has been the relatively short amount of time available to create new software elements within the ACE mission schedules. All identified building blocks must be based on existing software or ongoing development efforts. For ACE, only mission-specific software elements will be developed from scratch.

As a result of its analysis, the working group has defined a set of software elements for the ACE mission. Most of the elements chosen have a legacy in either the Packet Processor (Pacor) II or the Transportable Payload Operations Control Center (TPOCC). The challenge of the ACE implementation will be to bring these disparate systems together into a single entity. The final list of software elements is

- Production data processing
- Deep Space Network (DSN) monitor block processing
- Command echo processing
- Event logger
- Packet server
- Telemetry decommutation
- Data server
- Real-time subset generation
- High-speed subset generation
- File services
- History
- Ingest project database (ACE)

- Extract project database (ACE)
- Database
- Data distribution
- Time-division multiplexed (TDM) processing (ACE)
- Command link control word (CLCW) processing

This document serves as the formal proposal from the working group to the ACE mission team requesting these software elements be considered Renaissance building blocks for ACE. The notation (ACE) indicates ACE-specific building blocks. This represents a strong consensus of all the members of the group. Section 2 describes the transition of each of these elements from their legacy systems to the ACE MOC.

Section 2. Approach

Under the legacy approach (i.e., how ACE would have been implemented before Renaissance), the functions performed by Data Services would have been performed using a variety of institutional and mission resources. The following subsections describe each of these services, how they were performed under the legacy approach, and how the working group proposes that they be performed under the Renaissance plan. Table 2–1 illustrates the differences.

2.1 Production Data Processing

Traditionally, the Sensor Data Processing Facility performs production data processing, or LZP. LZP removes communications artifacts, such as duplicate packets, from the spacecraft data, reorders and regroups the received packets into datasets that reflect the order in which the data was collected on the spacecraft, provides quality annotations, and identifies missing packets. In the case of ACE, because the packets do not identify the spacecraft data source (application identifier), LZP will provide the data packets in spacecraft time order. Under the traditional approach, the Pacor II system would have provided this support. This facility operates independently of other spacecraft services, providing LZP services for a number of missions that adhere to the Consultative Committee for Space Data Systems (CCSDS) packet telemetry recommendations.

Under the Renaissance plan, the Pacor II production data processing subsystem (PDPS) will perform the LZP function as an integrated part of the ACE MOC. Instead of being a part of a separate facility, PDPS will operate within the MOC system and share external interfaces with other MOC data processing functions.

Future missions may consider using other LZP solutions, depending on the telemetry data rates. The Fast Auroral Snapshot Explorer LZP processor is a hardware-based alternative solution.

2.2 Deep Space Network Monitor Block Processing

DSN monitor block processing is a traditional Payload Operations Control Center (POCC) application that will remain essentially untouched for ACE. The MOC will receive monitor blocks from the DSN ground network to help the Mission Operations Team (MOT) in isolating ground communications problems. The DSN monitor block processing will extract parameters from the monitor block to facilitate this process. The ACE function differs from the traditional function in that the DSN-to-GSFC communications will use a Transmission Control Protocol/Internet Protocol (TCP/IP) network instead of the traditional NASA Communications (Nascom) serial network. The format of the block will change to accommodate the differences in the equipment.

Table 2-1. Proposed Renaissance Approach for ACE Data Services

Function	Pre-Renaissance Approach	Renaissance Approach
Production Data Processing	Pacor II	ACE MOC reusing pieces of Pacor II
DSN Monitor Block Processing	TPOCC	ACE MOC reusing pieces of TPOCC
Command Echo Processing	TPOCC	ACE MOC reusing pieces of TPOCC
Event Logger	By each system for each system	Integrated event handler within ACE MOC reusing pieces of TPOCC and Pacor II
Packet Server	Pacor II for real-time to external user; TPOCC Packet Extractor for internal TPOCC applications	ACE MOC reusing pieces of TPOCC
Telemetry Decommutation	TPOCC	ACE MOC reusing pieces of TPOCC
Data Server	TPOCC	ACE MOC reusing pieces of TPOCC
Real-Time Subset Generation	TPOCC	ACE MOC reusing pieces of TPOCC
High-Speed Subset Generation	TPOCC from playback stream	ACE MOC reusing pieces of TPOCC from LZP products
File Services	Individually at each system	Integrated in ACE MOC
History	TPOCC Pacor II GBRS	ACE MOC reusing pieces of TPOCC
Ingest Project Database (ACE)	Custom within POCC reusing some from XTE/TRMM	Custom within MOC reusing some from XTE/TRMM
Extract Project Database (ACE)	Custom within POCC reusing some from XTE/TRMM	Custom within MOC reusing some from XTE/TRMM
Database	Individually at each system	Integrated in ACE MOC
Data Distribution	DDF	ACE MOC using concepts from ISTP CDHF
TDM Processing (ACE)	Custom within POCC using playback stream	Custom within MOC using LZP products
CLCW Processing	Within external communications subsystem of TPOCC	Separate building block within MOC

2.3 Command Echo Processing

Command echo processing is a traditional POCC application that will remain essentially untouched for ACE. Before uplinking commands to the satellite, the DSN site returns a command echo to the MOC. The MOT uses this command echo to verify that the ground communications network has not corrupted the command being uplinked. The only difference between the traditional command echo processing function and the ACE function is that the command echo will travel via TCP/IP.

2.4 Event Logger

Traditionally, each of the independent Mission Operations and Data Systems Directorate (MO&DSD) entities has logged events to provide a historical record of mission operations. With the Renaissance concept, all mission operations will be performed in a single MOC. Therefore, the logging of events will be consolidated into a single event logger. However, the legacy systems that are being included in the ACE MOC each have their own way of capturing and reporting events.

The ACE event logger will combine the approaches of the Pacor II and TPOCC systems to satisfy the needs of the real-time operations staff for quick response and the needs of the data production staff for monitoring of nonreal-time processing and productivity reporting. This approach uses the TPOCC event logger to receive and serve events in real time. The ACE event logger will store events using relational database management system (DBMS) technology, as in Pacor II, to eliminate the need to create delogger functions and to allow customized browsing of the events.

2.5 Packet Server

Traditionally, near-real-time packet service has been divided between facilities such as Pacor II, which provides real-time service to external scientific users, and the POCC, which receives real-time packets for internal use.

For ACE, the MOC will provide all packet service. Initially, the working group thought that the Pacor II real-time output subsystem (RTOS) would route packets to external users, while the TPOCC packet server would route packets to internal MOC applications. After examining the requirements for real-time service to the ACE Science Applications and Archive Center and the ACE CCSDS packet structure, the working group determined that RTOS provided more functionality than needed. Therefore, the ACE MOC will use the TPOCC packet server for all packet routing.

Future missions may consider the use of the RTOS to provide packet routing services. The analysis should consider the need to route packets to multiple users based on application process identifiers (APIDs) and virtual channel identifiers (VCIDs).

2.6 Telemetry Decommutation

The POCC has traditionally performed telemetry decommutation in support of real-time operations. Telemetry decommutation requires near-real-time extraction of engineering and housekeeping information from telemetry packets and conversion of spacecraft data into engineering units. A TPOCC application exists to support this function and will be reused for the ACE MOC.

2.7 Data Server

The data server function provides real-time parameter routing to applications running within the POCC. This application provides a subscription service to applications that may request current parameter values, the next update to a parameter value, or a continuous series of parameter values. A TPOCC application exists to support this function and will be reused for the ACE MOC.

2.8 Real-Time Subset Generation

The POCC has traditionally performed real-time subset generation for real-time trending analysis. This application receives real-time engineering and housekeeping values and stores subsets of the values as they are received. The output of this application are used by the real-time trending subsystem. A TPOCC application exists to support this function and will be reused for the ACE MOC.

2.9 High-Speed Subset Generation

Code 510 is in the process of developing a high-speed offline subsetting function to provide trending input for analysis of playback engineering and housekeeping data. In the previous plan, this function was performed by replaying the playback telemetry stream. Because this stream was in receipt order and contained redundant data units, processing was required to time-order the results and remove redundant packets. Because LZP will remove these types of communications artifacts, the ACE MOC will use a high-speed subsetting application being developed for the TPOCC that uses the LZP product as input to generate the subset.

2.10 File Services

Traditionally, file services have been provided at each of the legacy facilities. The requirements for these services have been derived from the requirements of all missions to be supported with some factors included for growth and future unplanned missions. In addition to storage of data, the management services include archiving and backup of the data files.

For ACE, almost all of the file services will be provided inside the MOC. Therefore, the requirements for file services can be directly derived from the ACE requirements.

2.11 History

Traditionally, each of the legacy systems has provided its own history storage and replay. For Pacor II processing, history information has been captured using the Generic Block Recording System (GBRS) at the Nascom block level, by the quality analysis workstation subsystem (QAWS) for telemetry frame and packet level data, and by the Pacor information control subsystem for historical accounting data. For TPOCC, a set of history logging applications has been developed that captures data coming in and out of the TPOCC.

For ACE, the history function will be performed within the MOC. Because the TPOCC history logger functions provide the functionality needed, these will be reused. Modifying these functions to use a database instead of flat files is being considered. In addition, data production statistics from the PDPS will be stored and retrieved using the database.

2.12 Ingest Project Database (ACE)

The ingestion of the project database has been a traditional POCC function. Translating the database from the project database format into a format useful to the POCC applications has been necessary to ensure correct translation between POCC applications and spacecraft telemetry and commands.

The ACE MOC will reuse the application developed for the X-ray Timing Explorer/Tropical Rainfall Measuring Mission (XTE/TRMM) POCC.

For future missions, the use of the MOC system to maintain the project database should be considered. A single source of this information would greatly reduce the chance of translation errors.

2.13 Extract Project Database (ACE)

The TPOCC often needs to redistribute the project database or extract it into the original format to confirm it against the official database. To perform this function, applications are needed to extract the project database from the operational database.

The ACE MOC will reuse the application developed for the XTE/TRMM POCC.

For future missions, the use of the MOC system to maintain the project database should be considered. A single source of this information would greatly reduce the chance of translation errors.

2.14 Database

Like file services, each legacy system maintains its own database. Because these databases are used for setting up mission support and defining the telemetry received, much of the information is duplicated.

The ACE MOC will use a single ground data system database. The database will use the ORACLE relational DBMS. ORACLE was selected because it is used by both the TPOCC and the Pacor II systems. This selection reduces the amount of change required to standardize the database interfaces for ACE.

Future missions may consider the use of different relational DBMSs. They may even consider the use of multiple DBMSs for performance reasons. Interfaces to the database should be isolated and brought up to industry standards to reduce the effort needed to transfer applications to new DBMSs.

2.15 Data Distribution

Under the legacy plan, data from the ACE mission would have been distributed by the Information Processing Division's Data Distribution Facility (DDF). This facility receives and catalogs data from a variety of sources, including Pacor II and the Flight Dynamics Facility (FDF), and distributes the data to a variety of users.

ACE has a very limited number of data product recipients, including MOC, ASAAC, and FDF. Therefore, the requirements for data distribution are much less stringent than for most missions served by facilities such as DDF. Consequently, a new building block is being proposed to handle data distribution. This building block will catalog data files received and using pre-defined distribution specifications, route the data via the file transfer protocol to remote sites. In addition to electronic delivery, this building block will format and output data files to a commercial off-the-shelf compact disk, read-only memory drive.

Future missions may wish to consider the use of the institutional DDF for distribution. Criteria to be examined include the complexity of data sets, the number of users, and the media to be used.

2.16 Time-Division Multiplexed Processing (ACE)

In many ways, ACE is a transitional mission. While the telemetry data is nominally in CCSDS virtual channel data unit (VCDU) and packet formats, the spacecraft actually will wrap these formats around TDM major and minor frames. For ACE, Data Services has requirements to provide major and minor frame accounting from the playback data. The ACE operations concept further complicates this issue. As the satellite plays down data, VCDUs may be lost in the transmission. The MOT has the option to command the satellite to replay the sections of the recorder containing the missing VCDUs, resulting in the missing data being received along with some redundant VCDUs. Under the old concept, analysis would have to be performed to remove the effect of these artifacts. After reviewing these requirements and the ACE architecture, the Data Services Working Group decided to specify an ACE-specific building block to perform this accounting function on a post-pass basis, using a standard LZP product. The LZP product is already sorted by spacecraft time and redundant packets have been removed. This approach is only feasible because the LZP functionality is built directly into the ACE MOC.

Future missions will probably not have the same requirements for TDM processing. Therefore, this building block will probably not become a Renaissance building block. However, the same development standards that apply to Renaissance building blocks should be applied to this, and other mission-specific building blocks to ensure compatibility with Renaissance interfaces.

2.1.7 Command Link Control Word Processing

In the legacy plan, CLCW processing would have been performed in conjunction with VCDU statistics in the TPOCC. For ACE, the CLCW will be stripped out during packet extraction and provided by Spacecraft Communications Services to Data Services. Data Services will then strip the parameters from the CLCW and provide translations as needed. The parameters will then be offered for use via the system variable table.

Abbreviations and Acronyms

ACE	Advanced Composition Explorer
APID	application process identifier
CCSDS	Consultative Committee for Space Data Systems
CDHF	Central Data Handling Facility
CLCW	command link control word
DBMS	database management system
DDF	Data Distribution Facility (also known as DDFI)
DSN	Deep Space Network
FDF	Flight Dynamics Facility
GBRS	Generic Block Recording System
IP	Internet Protocol
ISTP	International Solar-Terrestrial Physics
LZP	level-zero processing
MOC	Mission Operations Center
MO&DSD	Mission Operations and Data Systems Directorate
MOT	Mission Operations Team
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications
Pacor	Packet Processor
PDPS	production data processing subsystem
QAWS	quality analysis workstation subsystem
RTOS	real-time output system
TCP	Transmission Control Protocol
TDM	time-division multiplexed
TPOCC	Transportable Payload Operations Control Center
VCDU	virtual channel data unit
VCID	virtual channel identifier
XTE	X-ray Timing Explorer